

12. **D**—Black lung disease is an occupational hazard of coal mining, which causes inflammation and scarring of the lungs due to the long-term breathing of coal dust.
13. **C**—Whale oil was plentiful during the early years of the whaling industry and was used for lighting.
14. **B**—Kerogen is a fine-grain sedimentary rock also called oil shale.
15. **D**—Strip mining shears away rock and soil to get to deeper resource-bearing layers leaving huge amounts of waste rock, polluted water, and openly erosive surfaces.
16. **E**—The Alaska Arctic National Wildlife Refuge (ANWR) is home to thousands of caribou as well as millions of other species that ecologists fear will lose critical habitat during energy exploration.
17. **B**—Chemical pollutants, soot and other particulates are released during coal burning.
18. **D**—When coal is burned, around 65% of its energy is lost at the plant during thermal conversion to electricity.

## Free-Response Questions

- The People's Republic of China leads the world in reliance on coal as a fuel source. Coal accounts for around 70% of China's energy production and has fueled the country's swift rise in the global market. China's ever-increasing industrialization continues to increase the country's dependency on coal as its main fuel source. Though demand is currently outpacing production, China has enough coal reserves to sustain its economic growth for another century.
  - What are the benefits of using coal over other fossil fuels?
  - What problems might China face in its reliance on coal as a fuel source?
  - What steps can China take to minimize the social and environmental risks of coal use?
- The second law of thermodynamics states that the universe tends toward entropy (e.g., randomness). In terms of energy use, this means a fraction of an original energy amount is always lost after changing to another form. For example, much energy is lost through heat from turbines in a hydroelectric power plant.
  - Can lost electric energy be retained?
  - What modern materials might make energy transmission more efficient?

## Free-Response Answers and Explanations

- The main reason coal provides a much better fuel source than other fossil fuels like oil and gas is because there is so much more of it. Global coal deposits are about 10 times greater than conventional oil and gas resources added together. Further, because it has been mapped and found economically recoverable, it is a proven resource. Though also a limited resource, it is extremely abundant.
  - Coal production for electricity can be extremely harmful to both the environment and public health. The process, from mining to waste disposal, creates both public and environmental risks. Because of hazardous substances contained within it (like mercury, sulfur dioxide, nitrogen oxides, and particulates), when coal is burned, it contaminates the air, land, and water.

- c. Clean coal technology exists to help stem the tide of problems associated with using coal to produce electricity. Gasification can be used to convert coal into carbon monoxide and hydrogen, which can then be used as a fuel called synthetic gas. Chemicals can be used to wash the minerals and impurities out of coal, and flue gases can be treated with steam to prevent sulfur dioxide from escaping into the environment. Beyond clean coal technology, China can use alternative fuel sources like solar and wind power to help offset the current socioeconomic and environmental costs of coal use.
- 2.
- a. Energy can be retained by keeping the amount and number of losses to a minimum.
  - b. Engineers and scientists are excited about the capabilities of carbon nanotubes as electrical transmission conduits. Individual carbon nanotube fibers have an electrical conductivity better than copper at only one-sixth the weight and with negligible current loss. Several researchers have demonstrated that a single-walled carbon nanotube can carry currents up to 20 microamperes. With current technology, losses in power transmission lines are about 7%. Dropping these losses to 6% would reap a national annual energy savings of  $4 \times 10^{10}$  kilowatt-hours (i.e., equal to about 24 million barrels of oil).

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- The first law of thermodynamics explains that energy can be neither created nor destroyed.
- The second law of thermodynamics describes how the universe tends toward entropy (chaos, disorder, or randomness).
- In 1956, Shell Oil geophysicist M. King Hubbert calculated that the oil well extraction rate in the United States (lower 48 states) would peak around 1970.
- Fossil fuels are solids, liquids, and gases created through the compression of ancient organic plant and animal material in the Earth's crust.
- Currently, oil production in the United States from all sources is around 8 million barrels a day from over a half million wells.
- Fossil fuels produce around 85% of U.S. energy, with oil making up about 40% of that.
- Fossil fuel burning is the biggest single source of human-created air pollution in the industrialized world.
- Getting additional oil from a drilled deposit is known as secondary recovery.
- Canada is the biggest supplier of oil to the United States.
- In 1839, Abraham Gesner, a governmental geologist in Nova Scotia, discovered albertite, a coal-like material. Later he discovered a process to manufacture kerosene.
- Kerosene, or "coal oil," was cheap and smelled better than animal fat when burned.
- When coal is used to produce electricity, nearly 65% of the original energy is lost in thermal conversion at the plant.
- One calorie unit equals the amount of energy needed to heat 1 gram of water to 1 degree Celsius.
- The *International Energy Outlook 2008* projects that global energy consumption will increase by 50% from 2005 to 2030.
- Coal is often contaminated with sulfur, sometimes as much as 10% by weight.
- The *International Energy Outlook 2008* estimates that coal will account for 29% of total world energy consumption in 2030.
- Coal burning creates a lot of atmospheric pollution and particulates, and increasing its use will worsen the global greenhouse problem.